2006 DOE/NETL ENVIRONMENTAL CONTROLS CONFERENCE

SESSION 2: TECHNIQUES FOR MANAGING SULFUR TRIOXIDE

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SO_3 INTRODUCTION/OVERVIEW

William Ellison PE
Ellison Consultants
Monrovia, MD 21770-9316

PURPOSE OF INITIAL, 1998, ONLY PRIOR, DOE SO_3 CONFERENCE

- GUIDE NEW RESEARCH
- CHARACTERIZING THE SO_3 PROBLEM
- ADDRESS SO_3 INTERFERENCES
- ASSESS UNCERTAINTIES
- INTEGRATE ACTION WITH EPA

[1998]

INITIAL, YEAR-1998, TRI REPORTING TO GOVERNMENT BY ELECTRIC UTILITIES

	% OF TOTAL TOXINS
HCl	50
SO_3/H_2SO_4	25*
Other	25
Total	100

*Electric utility industry rivals chemical industry in annual mass amount of emission.

[1998]

ADDITIVE USE IN SO_3 ABATEMENT UPSTREAM OF RAW GAS PARTICULATE COLLECTOR

- Ammonia
- Magnesia

[1998]

DISTRIBUTION OF H_2SO_4(L), ACID MIST, THAT FORMS IN THE AIR PREHEATER

- Sorption by fly ash, gasborne or deposited
- Flue gas exit stream
- Leakage to combustion air stream

[1998]

INDICATION OF POTENTIAL PROBLEMS ABSENT SCR (AND ITS CATALYTIC, SO_2-TO-SO_3 CONVERSION)

- Average SO_3 concentration may be as high as 50 ppm, exceeding 3% of gross SO_2 content.

- With unique, high iron content, e.g. western Kentucky coal: up to 10% conversion of SO_2 to SO_3 occurs.

[1998]

UNIT-WIDE SO_2/SO_3 BEHAVIOR

- An increment of SO_3 generation occurs in the furnace.
- Temperature-dependent, catalyzed SO_2-to-SO_3 conversion occurs in the convective pass, reaching a maximum rate at 1,300°F (704°C) flue gas temperature.
- Rate of SO_3 formation by SCR, increasing SO_3 perhaps by 20± ppm, is greatest at 660-750°F (350-400°C) and above.
- Below 600°F (316°C) SO_3 hydrates to gaseous sulfuric acid: H_2SO_4(v).
- Condensation of H_2SO_4(v) occurs at and below the sulfuric acid dew point temperature, typically as high as 280°F (138°C).

[1998]

INFLUENCE OF SOOT BLOWING

- Low-temperature blowing/cleaning (1,100 to 1,600^{o}F, i.e. 593 to 871^{o}C), in removing deposits, increases the rate of SO_2-to-SO_3 conversion due to tube-metal surface effect.
- However, (contrariwise), presence of such ash deposits, typically iron-oxide-laden, significantly increases SO_3 formation.

[1998]

INSIGHTS FROM MARCH, 1998, (MOST RECENT) DOE/FETC CONFERENCE ON SO_3

- A boiler model study showed that the condition of superheater tube surfaces radically influences catalytic SO_3 formation:

  - CLEAN: 20 ppm
  - MODERATELY FOULED: 70 ppm
  - HEAVILY FOULED: 32 ppm

- A large, high-SO_3, electric utility unit (without SCR) achieves 60% removal of SO_3 in the air preheater leading to its significant fouling (and derating). Across its exit cross-section, SO_3 varies laterally from 10 to 25 ppm.

[1998]

IMPACT ON AIR PREHEATER OF H_2SO_4 CONDENSATION IS EXACERBATED BY:

- Air to gas-side leakage
- Displacement of flue gas into air stream
- Enhancement of corrosion due to acid-wetted ash/salt deposit

[1998]

SCR CONCERNS RE SO_3 (AND NH_3)

- Design for 70% max. NO_x removal.
- Limit ammonia slip to 5 ppm.
- Avoid a potential SCR increase in SO_3 of 20 ppm.

[1998]

- If A Unit Has Significant, Air-Preheater-Related, SO_3 Problems, SCR Retrofitting Can Be Expected To Make The Situation Worse.

- If An Uncontrolled Unit Does Not Have Significant SO_3 Problems, Adequate SCR Retrofit System Design and Operation Should Not Lead To Increased Problems in Boiler System Performance or Maintenance.

CANDIDATE METHODS FOR MEASUREMENT OF SO_3 CONCENTRATION

- Controlled Condensation method (CONSOL, Inc.)
- Severn Science, wet-chemistry, continuous analyzer (Environmental Energy Services)

[1998]

ACTION OF VANADIUM IN PETROLEUM-BASED RESIDUAL FUELS

- Residual Fuel Oil: 100 ppm SO_3 periodically
- Petroleum Coke: 158 ppm SO_3 peak value

OPERATION OF WET SCRUBBERS

- 0 to 70% $SO_3/H_2SO_4(v)$ removal
- 0% $H_2SO_4(L)$ removal
- Variable degree of conversion of $H_2SO_4(v)$ to $H_2SO_4(L)$, sulfuric acid mist aerosol, in the air preheater

[1998]

OPERATION OF DRY SCRUBBERS

- Non water-saturating design
- 98-99% $SO_3/H_2SO_4(v)$ removal, (greater than that of SO_2)

THRUST OF 2006 SO_3 CONFERENCE

- Emphasis on high-sulfur coal
- New data on rate of boiler SO_3 formation
- Broad benefits of depressing SO_3 concentration
- Wet ESP advancements: membrane type, new Siemens type
- Role of CFD Modeling

Con't →

- Sorbent technology/technique:
  - Lime
  - Trona
  - Sodium bisulfite/carbonate
  - Magnesium hydroxide
- Tie-in with mercury control
- Tie-in with SCR catalyst and air preheater operation
- Semi-continuous SO_3 emission monitoring